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Primary Dendrite Arm Spacing and Trunk Diameter in Al-7 wt% Si Alloy Directionally Solidified Aboard the International Space Station

Under a NASA-ESA collaborative research project, three Al-7 wt% Si samples (MICAST-6, MICAST-7 and MICAST 2-12) were directionally solidified aboard the International Space Station to determine the effect of mitigating convection on the primary dendrite array. The samples were approximately 25 cm in length with a diameter of 7.8 mm diameter cylinders that were machined from [100] oriented terrestrially grown dendritic Al-7Si samples and inserted into alumina ampoules within the Sample Cartridge Assembly (SCA) inserts of the Low Gradient Furnace (LGF). The feed rods were partially remelted in space and directionally solidified to effect the [100] dendrite-orientation. MICAST-6 was grown at $5 \mu\text{m s}^{-1}$ for 3.75-cm and then at $50 \mu\text{m s}^{-1}$ for its remaining 11.2-cm of its length. MICAST-7 was grown at $20 \mu\text{m s}^{-1}$ for 8.5-cm and then at $10 \mu\text{m s}^{-1}$ for 9-cm of its remaining length. MICAST2-12 was grown at $40 \mu\text{m s}^{-1}$ for 11-cm. The thermal gradient at the liquidus temperature varied from 22 to 14 K cm^{-1} during growth of MICAST-6, from 26 to 24 K cm^{-1} for MICAST-7 and from 33 to 31 K cm^{-1} for MICAST2-12. Microstructures on the transverse sections along the sample length were analyzed to determine nearest-neighbor spacing of the primary dendrite arms and trunk diameters of the primary dendrite-arrays. This was done along the lengths where steady-state growth prevailed and also during the transients associated with the speed-changes. The observed nearest-neighbor spacings during steady-state growth of the MICAST samples show a very good agreement with predictions from the Hunt-Lu primary spacing model for diffusion controlled growth. The observed primary dendrite trunk diameters during steady-state growth of these samples also agree with predictions from a coarsening-based model. The radial macrosegregation and “steeping” caused by thermosolutal convection during terrestrial growth of the Al-7Si was not observed in the space-grown MICAST samples.